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ENERGY BALANCE OF A 1-HA ALGAE PLANT FOR THE PRODUCTION OF HIGH QUALITY ALGAE BIOMASS

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Keywords: algae, microalgae, EROEI, energy balance

The energy balance of a 1-ha scale microalgae production plant was analyzed. The plant is located along the Mediterranean seacoast (e.g. Morocco costs) and close to a CO_2 source, to be able to work for at least 330 days per year. The plant area is occupied with 1.000 m^2 of closed photobioreactors (GreenWall Panels®-II) and 9.000 m^2 of open ponds (raceway ponds). Five main areas constitute the plant: inoculum production, first and second growth stages, harvesting and ancillaries (water treatment, medium preparation, etcetera).

The analysis has been developed to evaluate the EROEI (defined as the ratio between the energy output and the primary energy required for production) of the microalgae production stage, harvesting and concentration of the biomass. Further downstream processes have not been considered as they are strongly dependent on the final market of the plant output.

The production of the wet algae paste requires 284 kWh_{el} ha^{-1} d^{-1}, corresponding to a primary energy of 490 kWh ha^{-1} d^{-1}. In order to evaluate the EROEI, a productivity of 20 g m^{-2} d^{-1} is considered, with a Gross Heating Value (GHV) of 7.1 kWh kg_{algae}^{-1} for the dry algae, resulting in a total output of about 1417 kWh ha^{-1} d^{-1}. The corresponding EROEI for the cultivation phase resulted 2.9.

Considering only the cultivation phase gives an incomplete balance of the plant energy performance, thus a harvesting section has been defined and included. A cross-flow ultra-filtration, followed by centrifugation allows to harvest biomass with characteristics suitable for many further downstream processes. Adding harvesting, the electrical plant consumption increases to 516 kWh_{el} ha^{-1} d^{-1}, corresponding to a primary energy of 889 kWh ha^{-1} d^{-1}. The resulting EROEI of the plant is thus 1.6.

This result does not include the energy demand for fertilizers and the embodied energy of the materials of the plant. However, this balance based on electrical consumption allows to highlight the critical sections of the plant: the greater (largest) consumption is related to harvesting (about 46%), followed by culture mixing (about 25%) and CO_2 supply (21%).

Considering also the embodied energy of the materials used, as well as the energy associated with the production of fertilizers, the resulting total primary energy accounts for 1123 kWh ha^{-1} d^{-1}, with a corresponding EROEI of 1.3.

The EROEI evaluation of the 1-ha plant showed that the most relevant input is associated with the harvesting; thus, innovations should be focused on this process step, so as to increase the competitiveness of the algae production sector.

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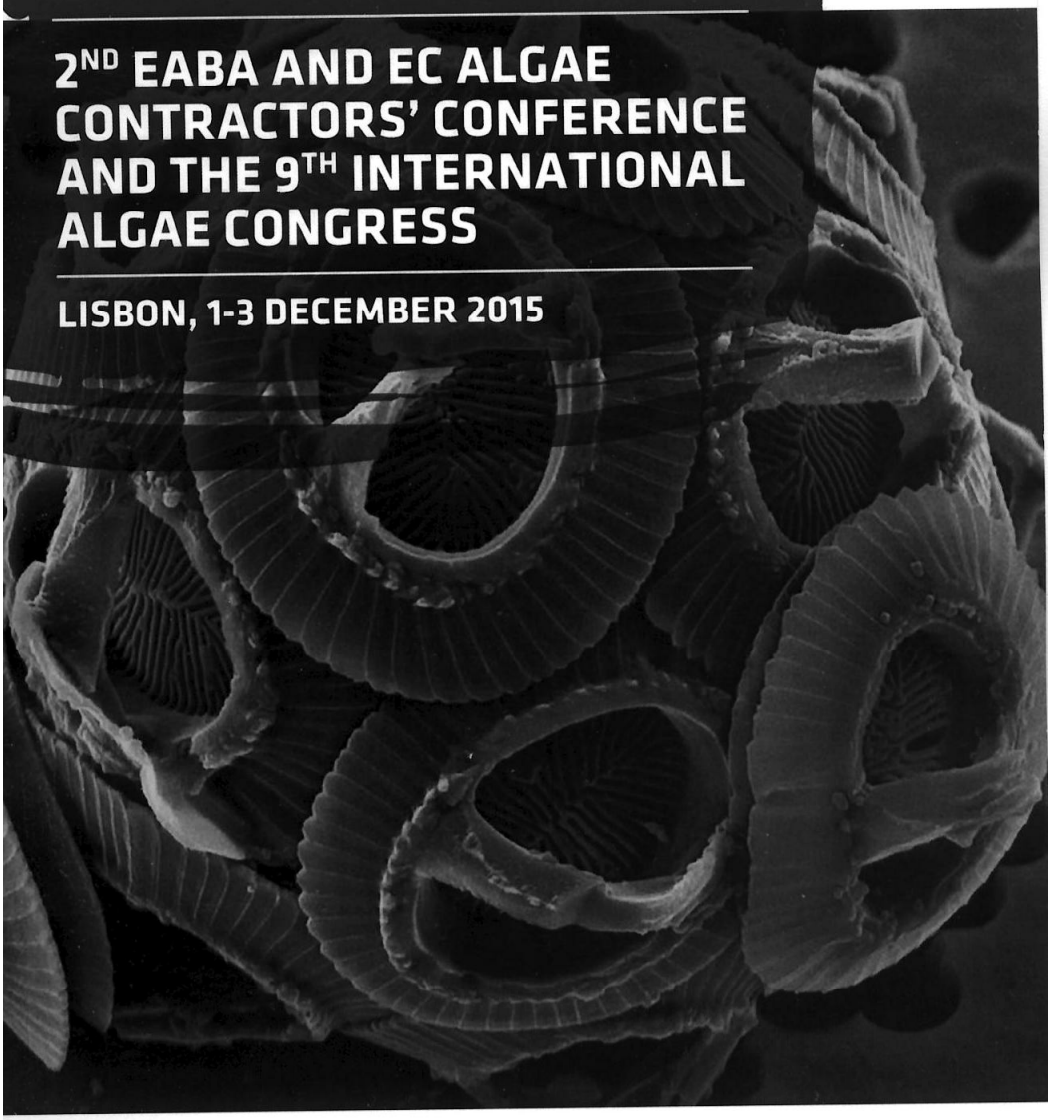

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